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ACIOL, sutured PCIOL, or glued IOL: Where do we stand?

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Summary

Many clinical circumstances require extracapsular IOL fixation and multiple options exist in the setting of inadequate capsular support. Ultimately, there are many factors that must be considered in selecting an appropriate surgical approach. These include ocular history as well as the skill, experience, and comfort level of the individual surgeon. The myriad of options that now exist for IOL fixation increases the likelihood that patients with a wide variety of pathologic states will attain their best possible visual outcome.

Keywords

lens dislocation; intraocular lens fixation; intraocular lens complication

Introduction

Ideally, surgical extraction of lenticular material and intraocular lens (IOL) placement is accomplished as a single procedure resulting in a centered IOL stably supported by the native capsular bag. There are, however, many circumstances that compromise this ideal, necessitating creative surgical solutions to enable stable IOL placement and optimal visual outcomes. This review will discuss recent developments in the surgical management of complicated lenticular disease states in which an IOL cannot be securely supported by the native capsular bag.

General Types of IOL Fixation

When endocapsular placement is not possible, the most widely used approaches include (1) fixation to the sclera (with or without sutures), (2) fixation to the iris by suturing or iris claw, or (3) support by the anterior chamber angle. Each has strengths and weaknesses with respect to surgical difficulty, operative time, and intraoperative and/or post-operative complications.

Indications

The basic indication for scleral, iris, or anterior chamber angle fixation is lack of posterior or anterior capsular support. This occurs when the capsule becomes damaged or dislocated, or is inherently weakened as part of an underlying disease process. Common sources of capsular damage include trauma and complicated cataract surgery. Severe infectious or inflammatory processes such as endophthalmitis or uveitis may also compromise capsular

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strength. Marfan's syndrome, homocystinuria, Weill-Marchesani syndrome, sulfite oxidase deficiency, and pseudoexfoliation syndrome are some of the diseases that alter zonular integrity and therefore capsular stability.

Trauma

Severe blunt ocular trauma or penetrating injury may result in loss of capsular support [1–2]. All of the major fixation techniques have been reported in cases of post-traumatic cataract extraction and IOL implantation. If injury to the iris occurs, angle supported or iris-sutured fixation may not be tenable. Most recent series have described scleral fixation strategies for IOL placement after trauma [3–9].

Complicated Cataract Surgery

Alternate fixation strategies are often needed following complicated cataract surgery. IOL placement may occur at the same time as complicated cataract extraction, or as a secondary procedure at a later date [2,*8]. Capsular weakness is not always recognized at the time of complicated cataract surgery, which may lead to late IOL dislocation. A recent study of 36 consecutive patients with out-of-the-bag IOL dislocation found the most common risk factor to be posterior capsular rupture during initial cataract extraction [10]. Other studies have examined outcomes and strategies for the management of late in-the-bag IOL dislocation. In many cases, cataract extraction may proceed uneventfully but lead to the gradual development of capsular or zonular weakness and eventually, IOL dislocation [2, *11].

Lens Subluxation

Crystalline lens subluxation occurs in 60% of patients with Marfan syndrome [12]. Subluxation is initially managed with spectacle or contact lenses. When visual acuity is no longer correctable with these approaches, surgical lens removal with IOL fixation is indicated [**13]. Several recent series have included patients with ectopia lentis, typically due to Marfan syndrome [*8, **13– 15].

Dislocation of a previously placed IOL is a common indication for subsequent extracapsular fixation. In many cases it is desirable to proceed with repositioning and either scleral- or iris-based fixation of the existing IOL [*11, 16–17]. Use of capsular fixation to the sclera has been described using either a Type 1 or Type 2 Cionni capsule tension ring, enabling in-the-bag intraocular lens placement [18].

Lens Replacement/Exchange

In some cases, a previously placed IOL may be dislocated or cannot be retained, and surgery is required for IOL removal and replacement. A recent case series reviewed 45 cases of late in-the-bag IOL dislocation recommends repositioning if the superior optic edge remains above the central visual axis. Repositioning can be performed using anterior optic capture of a 3-piece intraocular lens or by implantation of a capsule tension ring to recenter the capsule. For displacement of the superior optic edge below the central visual axis, lens replacement was performed [*11]. Other indications for lens replacement include IOL damage, excessive residual lens material, and an IOL model that is not amenable to suturing or other means of extracapsular fixation (eg., plate haptic).

Another potential indication for lens replacement is pseudophakic bullous keratopathy (PBK). This complication occurred more frequently in certain older AC-IOL models [19–20]. Although the incidence of PBK is lower in newer AC-IOL lenses [21], they should be removed if there is endothelial decompensation or if there is shallow anterior chamber depth (< 3mm).

Overview of Surgical Techniques

Excellent technical reviews of many major extracapsular fixation approaches are available [2]. We briefly overview the major techniques, but a detailed review of surgical techniques is beyond the scope of this article.

Calculation of IOL Power

Calculation of proper lens power is critical for any procedure involving IOL placement. If a history of trauma exists, it may not be possible to obtain reliable biometry on the injured eye [1]. Several recent studies suggest that measurements obtained from the uninjured fellow eye may be used in such circumstances [4–5, 7].

Traditional IOL power calculations are based on endocapsular IOL localization. Several authors recommend adjusting the calculated IOL power to account for changes in IOL location [3, 22]. Proper IOL power adjustment is more important in eyes which require higher power lenses. In general, IOL power should be decreased as the lens is positioned further anteriorly within the eye (typically by a half or full diopter for placement in the ciliary sulcus or iris fixation). Most recent studies of extracapsular fixation report using the SRK II formula for baseline IOL power calculation [3–*6, 23–24].

Sutured Scleral Fixation

Scleral fixation is most commonly approached *ab externo*, meaning that sutures are passed initially from outside to inside in order to establish IOL capture and eventual fixation. In this case, ciliary sulcus location is established by external landmarks, usually distance from limbus. A recent case series describes a novel technique involving intraocular endoscopy to pass sutures *ab interno* under direct visualization, ensuring ciliary sulcus localization [*8]. Most authors prefer double-armed polypropylene suture (Prolene), size 8–0, 9–0 or 10–0 for sutured scleral fixation. Polyester (Mersilene), polyethylene (Novafil), or polytetrafluoroethylene (Gore-tex) have also been described as suture materials. Techniques using both straight (STC-6) and curved needles (CIF-4 or CTC-6) have been described. Straight needles provide longer range of access, while curved needles provide more needle rigidity.

Scleral flaps [4–5, 9, 25–27], tunnels [16, 28], or grooves [3, 29] are created to facilitate access to the ciliary sulcus, protect the knot, and prevent external suture erosion. Some techniques avoid conjunctival dissection [16] or utilize sliding knots that tighten internally, eliminating the need to bury or rotate a fixation knot [30]. Often, hollow needles (eg., 27 gauge) are used as a docking guide to ensure exit of the suture needle through the appropriate scleral flap or groove [3–5, 25–28]. Several IOLs have haptics bearing eyelets to aid in suture fixation; the Alcon CZ70BD is the most commonly used lens with the eyelet on haptic design. Other techniques describe tying knots directly to the haptic arm itself [26, 31].

Sutured scleral fixation is often used to surgically reposition dislocated lenses, allowing for retention of a previously placed IOL. If the IOL remains within-the-bag, repositioning of the entire IOL-capsular bag complex can be achieved. A Cionni Type 1 or 2 capsular tension ring can be used for this purpose. Some techniques specifically guide the suture needle through portions of the capsular bag in order to achieve better stability of the IOL-capsule complex [30, 32–33].

Sutureless Scleral Fixation

Sutureless scleral fixation involves externalizing IOL haptics for fixation within the sclera. Techniques involve either the use of scleral flaps [34–35] or limbus-parallel scleral tunnels

[14, 36–37]. *Ab externo* straight sclerotomies are performed at the ciliary sulcus. Small (25 gauge) forceps [14, 34, 36–37]. or a hollow 25 gauge needle [35] are used to grasp/secure and subsequently externalize one haptic at a time through the appropriate sclerotomy. Once externalized, the haptic is securely situated beneath the previously formed scleral flap or within the previously formed scleral tunnel. If a scleral flap is used, it may be closed with 10–0 nylon [35] or with fibrin glue [*6, 34, 38].

Sutureless scleral fixation is theoretically compatible with multiple different IOL types and does not require specialized haptics containing suture eyelets. Recent studies have reported the use of fibrin-glue assisted techniques combined with DSAEK [24] and as a means for fixation of IOL-iris prosthesis in aniridia [38]. However, to minimize haptic torsion and scleral traction, several authors recommend that sutureless scleral fixation be used with IOLs designed to fit the entire ciliary sulcus [14, 35–36].

Sutured Iris Fixation

Most reports describing sutured iris fixation involve directly suturing an IOL haptic to the iris midperiphery. However, techniques outlining direct suturing of an IOL optic to the iris have been reported [39–40]. Suture and needle selection are similar to scleral sutured approaches, and most authors prefer 9–0 or 10–0 polypropylene with long curved needle, CIF-4 or CTC-6 needle [**13, 41–42].

Suture passes generally enter and exit the eye in the peripheral cornea or limbal region, and incorporate full thickness bites through midperipheral iris. Often, hooks are used to guide needle passes and/or loop suture out through the appropriate exit site [**13, 42]. Suturing strategies include modified McCannel [*11, **13, 43] or Siepser knot [41, 44] techniques. Recently, a novel approach has been described using a girth-hitch knot [42].

Iris Claw Fixation

Sutureless iris fixation may be accomplished in the setting of specially designed IOLs in which haptics are replaced by an “iris claw.” During enclavation, a small knuckle of iris tissue is captured by the fixation hole or “claw” located on either side of the lens. Key parts of the procedure include the use of (1) miotic to maximally constrict the pupil leading to better exposure of iris tissue, (2) viscoelastic to create space and minimize corneal endothelial trauma, (3) a second instrument to stabilize the body of the lens while the enclavation needle is used to fixate the IOL, and (4) peripheral iridotomy.

While iris claw lens use is well-described in phakic patients [45–48], they have also been utilized in cases of aphakia or IOL exchange [*11, **13, 15, 49]. A recent case series describing 23 cases of severe IOL dislocation managed by IOL replacement/exchange concluded that iris claw lenses were less invasive and relatively easy to place [*11].

Prognosis/Outcomes

In general, patients with extracapsular IOL fixation have good visual outcomes. Essentially all recent case series report improved visual acuity in a majority of patients. Poorer visual outcomes are often related to ocular comorbidities associated with the underlying pathology necessitating extracapsular fixation. Most reports describe a series of patients who have undergone one specific fixation technique making it difficult to compare outcomes among the many different techniques. There have been few studies that directly compared different fixation techniques, and most of these are retrospective. The most recent comparative studies will be briefly described below.

In a retrospective review of 82 consecutive patients (36 patients with scleral fixation and 46 with AC IOL implantation), there was a statistically significant difference in post-operative best corrected visual acuity favoring the AC IOL group at 3 years postoperatively [50]. In a prospective study of 31 eyes in 16 patients with Marfan's syndrome and crystalline lens subluxation, similar visual outcomes at 1 year were found between iris suturing and iris-claw ACIOLs [**13]. In a prospective study of 71 eyes in 49 patients with Marfan syndrome and crystalline lens subluxation, there was no significant difference in outcome at 1 year between patients randomly assigned to either iris-claw AC IOL placement (32 eyes) or PC IOL implantation through sutured scleral fixation (39 eyes) [15].

In a series of 166 patients who underwent PPV following complicated cataract surgery, multivariate analysis found that primary placement of a posterior chamber IOL was associated with better final visual acuity (these patients were three times more likely to have 20/40 vision or better). Aphakia at time of PPV was associated with poorer outcomes. There was a trend toward poorer visual outcome with AC-IOL, but this was not statistically significant [51].

Complications

Differences in tissue involvement and IOL localization affect the surgical risk profile and should be considered when weighing which surgical approach is most appropriate for a specific patient.

Anterior chamber angle supported lenses are in close proximity to the cornea and anterior chamber angle, increasing risk for bullous keratopathy, glaucoma, and peripheral anterior synechiae [*11, 52–55]. Anterior chamber iris-claw lenses are also in close proximity to the cornea, but midperipheral iris fixation may decrease the concern for angle-related complications [**13, 46]. Assessment of anterior chamber depth is essential. Concern for long-term complications has led some authors to recommend that anterior chamber lenses be avoided in young (< 50 years old) patients [2, 56].

Sutured scleral fixation involves passing sutures through uveal tissue, which may lead to retinal detachment or intraocular hemorrhage [3, 5, 7–*8, *11, 15, 30]. Risks are higher in myopes, hypertensives, or patients on anticoagulants. Externalized suture and knots can increase risk for suture or tissue erosion and endophthalmitis. Late IOL dislocation or tilt is also a potential concern with scleral fixation techniques [*8, *11, 15, 26, 35].

Sutureless scleral fixation requires sclerotomy and externalization of haptics through uveal tissue, which may induce intraocular hemorrhage [*6, 14]. Techniques involve fixation of IOL haptics within partial thickness scleral flaps or tunnels. IOL stability relies upon the formation of intrascleral scar tissue surrounding the haptic [34]. There is a potential for torsional forces to be exerted on the haptic and/or the scleral tissue. Caution should be exercised in eyes with history of scleritis or conditions associated with scleromalacia.

Sutured iris fixation can potentially result in disruption of iris architecture leading to peripheral anterior synechiae, dyscoria, and limitation in subsequent pupillary dilation [2, **13]. There is also a risk of intraocular hemorrhage during needle passage and some risk of chronic inflammation.

Conclusions

Many surgical options exist for patients requiring IOL placement without adequate capsular support. Fortunately, most patients enjoy good visual outcomes following extracapsular fixation. In patients without other complicating factors, several different options may be

equally likely to result in an excellent visual outcome. In such a circumstance, a simpler and faster surgical approach such as anterior chamber angle supported IOL may be desirable (although astigmatism remains a significant concern here). In other situations, specific approaches are not indicated or are technically impossible. Examples include avoidance of AC IOLs in cases with shallow anterior chamber depth and inability to place iris or angle-supported lenses after iris trauma.

Anterior chamber, iris-fixated, and scleral-fixated lenses are all viable options when used appropriately in the setting of inadequate capsular support [57]. Additional research with longer follow-up and comparative randomized trials are needed to determine if, over the long term, all options seem to be equally safe and effective.

Acknowledgments

Purpose To review the recent literature addressing the surgical approaches to intraocular lens fixation in the setting of inadequate capsular support.

Recent Findings Lack of capsular support is a commonly encountered problem facing the anterior segment surgeon. Recent reports suggest that visual outcomes are generally good with modern IOLs and surgical approaches. More recently described techniques include sutureless scleral fixation and intraocular endoscopy-guided suture placement.

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Key Points

(1) Multiple options exist for IOL fixation in the setting of poor capsular support.

(2) Anterior chamber angle supported, scleral-fixated, and iris-fixated approaches are all viable options for extracapsular IOL fixation when utilized appropriately.

(3) Anterior segment surgeons must be aware of specific circumstances where certain extracapsular fixation approaches are relatively contraindicated.

(4) Additional data from controlled, comparative studies is needed to best assess which extracapsular IOL fixation methods are appropriate for specific patient populations.